IN THE SPECIFICATION

Please amend paragraphs [0001] – [0012], [0017] – [0019], [0035] – [0039], [0041], [0044] – [0047], [0049], [0059] – [0061], [0063], [0067] – [0069], [0071] and [0074] as follows:

[0001] The present invention relates to a substrate treatment apparatus and a substrate treatment method for drying a substrate by spraying the air to the substrate using an air knife, and a substrate manufacturing method employing them. It especially relates to the substrate treatment apparatus and the substrate treatment method suitable for drying ~~the~~ a large-size substrate or ~~the~~ a substrate having ~~the~~ a strong water repellency ~~strongly~~ on its surface, and the substrate manufacturing method employing them.

[0002] In a manufacturing process of a panel substrate for a flat panel display, such as a liquid crystal display, a plasma display and the like, a chemical liquid treatment, such as development, etching, etc., is performed in order to form circuit patterns, a color filter, etc. on the substrate. Also in a manufacturing process of a semiconductor device, the chemical liquid treatment, such as development, etching, etc., is performed in order to form the circuit patterns, etc. on a substrate, such as a semiconductor wafer, etc. ~~And before~~ Before or after the chemical liquid treatment, it is required to wash the substrate using ~~the~~ washing water (pure water) and dry the substrate after washing. In many cases, a series of these processes, including washing and drying of the substrate, is performed while moving the substrate using ~~the~~ carrying equipment, such as a roller conveyer and the like. ~~And the~~ The substrate is usually dried by spraying ~~the~~ air onto the substrate, using an air knife, so that a treatment liquid, such as ~~the~~ washing water, etc., is pushed away and removed from a surface of the substrate.

[0003] ~~The~~ Japanese Patent Laid-Open 2002-252200 describes a technology for performing ~~the~~ a series of the processes to the substrate while moving the substrate. ~~And the~~ Japanese Patent Laid-Opens 2001-50660 and 2001-284777 describe a technology for drying ~~the~~ a substrate using ~~the~~ an air knife.

[0004] In a drying process using ~~the~~ an air knife, if the treatment liquid, such

as ~~the~~ washing water, etc., is distributed unevenly on the surface of the substrate, the treatment liquid will be removed unevenly so that drying stains will be generated on the surface of the substrate. For this reason, it was conventionally required to evenly form a treatment liquid layer ~~evenly~~ on the surface of the substrate before drying in order to evenly dry the substrate ~~evenly~~ using the air knife. However, since the area of the substrate has becomes larger due to the enlargement of the flat panel display in recent years, a large amount of the treatment liquid is needed in order to evenly form the treatment liquid layer ~~evenly~~ on the surface of the substrate.

[0005] Moreover, among the substrates washed and dried during the manufacturing processes of various displays or the semiconductor devices, there are some substrates that have a strong ~~having the~~ water repellency ~~strongly~~ on their surfaces to repel the washing water (pure water). For example, in a manufacturing process of ~~the~~ a color filter of ~~the~~ a liquid crystal display, a black matrix for shutting out the light, coloring patterns of RGB for displaying colors, a transparent protection film for protecting the coloring patterns, and transparent film electrodes for driving the liquid crystal, are formed on a glass substrate. ~~Especially,~~ The resin films for forming the black matrix and the coloring patterns especially have ~~the~~ a strong water repellency ~~strongly among these~~. For this reason, the surface of the substrate has ~~the~~ a strong water repellency ~~strongly~~ when the black matrix ~~or~~ and the coloring patterns are formed.

[0006] It is difficult to evenly form a washing water layer ~~evenly~~ on the surface of ~~the~~ a substrate, ~~which has the~~ that has a strong water repellency ~~strongly,~~. Therefore, ~~so that~~ areas without the washing water layer tend to appear on the surface of the substrate~~. Then,~~ and drops of the washing water, which are blown away with the air from the air knife, adhere to ~~the~~ those areas without the washing water layer and result in drying stains called watermarks. Although such watermarks ~~had been~~ have conventionally been permitted to some extent, they can ~~not~~ no longer be disregarded ~~anymore~~ since they cause a problem of appearance and surface resistance variations when the pitch of the circuit patterns, which are formed on the surface of the substrate, becomes finer and finer.

[0007] Moreover, a sloping carry system for performing ~~the~~ a series of ~~the~~ processes to the substrate while moving the substrate, ~~a sloping carry system,~~ which slopes the substrate at a certain angle from ~~the~~ horizontal while moving the substrate, is known (~~the~~ Japanese Patent Laid-Open 2001-108977). Especially in a washing process using the sloping carry system, the high washing effect is obtained since the treatment liquid, such as a developing solution, etching solution, etc., does not stagnate on the surface of the substrate but it is efficiently replaced with the washing water. Furthermore, the high foreign matter removal effect is obtained since the washing water also does not stagnate on the surface of the substrate so that foreign matters, which float out from the surface of the substrate, hardly adhere to the surface of the substrate again.

[0008] For the color filter mentioned above as an example, the washing process using the sloping carry system is strongly required since the resin films come off easily and many foreign matters remain as a residue when washing the substrate in a horizontal state. However, when ~~the~~ a substrate, which has ~~the~~ a strong water repellency ~~strongly~~ on its surface, is dried using the air knife while moving the substrate by the conventional sloping carry system, most of the washing water, which is supplied to the surface of the substrate, flows out of the surface of the sloped substrate before drying, and ~~few~~ a small amount of water remains on the surface of the substrate as small drops. Then, the ~~remained~~ remaining small drops of water are moved on the surface of the substrate by the air sprayed from the air knife. For this reason, there was a problem in that traces of the small drops, which were moved on the surface of the substrate, resulted in line-shape stains. Moreover, there was a problem that ~~the~~ foreign matters remained along the traces of the small drops, which were moved on the surface of the substrate.

[0009] The purpose of the present invention is to reduce ~~an~~ the amount of the treatment liquid used when drying the substrate using ~~the~~ an air knife.

[0010] Another purpose of the present invention is to prevent ~~the~~ watermarks from being generated and to dry the substrate evenly without ~~the~~ drying stains when drying the substrate using ~~the~~ an air knife.

[0011] Another purpose of the present invention is to dry the surface of the substrate, which has ~~the~~ a strong water repellency ~~strongly~~ on its surface, evenly, without ~~the~~ drying stains, while obtaining the high washing effect and the high foreign matter removal effect by the sloping carry system.

[0012] Another purpose of the present invention is to reduce the foreign matters ~~remained~~ remaining on the surface of the substrate, which has ~~the~~ a strong water repellency ~~strongly~~ on its surface, while obtaining the high washing effect and the high foreign matter removal effect by the sloping carry system.

[0017] By preparing the first/second flat component the predetermined distance apart above/below the substrate and filling the space between the first/second flat component and the substrate with the treatment liquid, it becomes possible to form the treatment liquid layer evenly on the upper/lower surface of the substrate using a less amount of the treatment liquid. Moreover, since the upper/lower surface of the substrate is covered by the first/second flat component, the drops of the treatment liquid, which are blown away with the air from the first/second air knife, do not adhere to the upper/lower surface of the substrate. Therefore, it becomes possible to prevent ~~the~~ watermarks from being generated.

[0018] Another feature of the present invention is spraying the air from the air knife to the surface of the substrate slantingly at a predetermined incident angle, and supplying the treatment liquid near from the air knife to the surface of the substrate slantingly at a predetermined incident angle in an opposite direction of the air from the air knife so as to form the treatment liquid layer on the surface of the substrate while moving the substrate, which has ~~the~~ a strong water repellency ~~strongly~~ on its surface, with the substrate sloped at a predetermined angle from ~~the~~ horizontal.

[0019] A boundary of the formed treatment liquid layer appears at a

position, where the power of ~~a~~ the flow of the supplied treatment liquid to push the layer, the power of the layer to move along a slope of the substrate and the power of the air from the air knife to push the layer away are balanced. Beside the boundary of the treatment liquid layer on the surface of the substrate, a side in a substrate moving direction becomes a dry area, where the treatment liquid layer is pushed away and removed by the air from the air knife. On the other hand, in a non-dry area in an opposite side, the treatment liquid layer is always formed with the supplied treatment liquid. Therefore, even if the substrate has ~~the~~ a strong water repellency ~~strongly~~ on its surface, the line-shape stains will not be generated ~~unlike before~~ since the treatment liquid layer has ~~being~~ been formed on the surface of the substrate just before drying. Moreover, ~~the~~ foreign matters do not remain ~~unlike before~~ along the traces of the small drops moved. ~~And~~ Also, the high washing effect and the high foreign matter removal effect are obtained by sloping the substrate at the predetermined angle from ~~the~~ horizontal while moving the substrate.

[0035] Above the substrate 1 mounted on the rollers 10, the upper board 12 is prepared ~~through~~ across a width of the substrate 1 in a direction perpendicular to the substrate moving direction, wherein the upper board 12 is a predetermined distance apart from the substrate 1 and in parallel with the substrate 1. On the upper board 12, the pipe 13 is installed at a certain position, which is shifted to the substrate moving direction from the center of the upper board 12. The pipe 13 fills a space between the upper board 12 and the substrate 1 with the washing water 2a by supplying the washing water at a predetermined flow rate. Thereby, a washing water layer is formed evenly on an upper surface of the substrate 1 when the substrate 1 passes below the upper board 12.

[0036] Below the substrate 1 mounted on the rollers 10, the lower board 14 is prepared ~~through~~ across the width of the substrate 1 in the direction perpendicular to the substrate moving direction, wherein the lower board 14 is a predetermined distance apart from the substrate 1 and in parallel with the substrate 1. In this example, a space between the lower board 14 and the substrate 1 is bigger than a diameter of the rollers 10, and the lower board 14 is located under the rollers 10. And the rollers 10 located over the lower board 14 are surrounded by

walls 14a, which are prepared at edges of the lower board 14. On the lower board 14, the pipe 15 is installed at a certain position, which is shifted to the substrate moving direction from the center of the lower board 14. The pipe 15 fills the space between the lower board 14 and the substrate 1 with the washing water 2b by supplying the washing water at a predetermined flow rate. Thereby, a washing water layer is formed evenly on a lower surface of the substrate 1 when the substrate 1 passes above the lower board 14.

[0037] Moreover, above the substrate 1 mounted on the rollers 10, the air knife 11a is prepared ~~through~~ across the width of the substrate 1 in the direction perpendicular to the substrate moving direction, wherein the air knife 11a is near the upper board 12 and in parallel with the substrate 1. And below the substrate 1 mounted on the rollers 10, the air knife 11b is prepared in the same way. The air knives 11a and 11b are constituted of a long casing, for example, wherein a pressure room is formed inside the casing and a slit-shape air passage led to the pressure room is prepared through it length. The air is supplied to the air knives 11a and 11b from the air supply equipment, which is not illustrated, and the air knives 11a and 11b emit the air from an end of the air passage evenly through its length. As shown by arrows of a broken line in the figure, the air, which is emitted from the air knives 11a and 11b, is sprayed to the upper/lower surface of the substrate 1 slantingly at a predetermined incident angle in an opposite direction of the substrate moving direction. Thereby, the washing water is pushed away and removed from the upper surface of the substrate 1, which passes below the upper board 12, and the lower surface of the substrate 1, which passes above the lower board 14.

[0038] Figure 2 is a side view including some sections showing another example of the substrate treatment apparatus according to the present invention. This example differs from the example shown in Figure 1 ~~in point of~~ with respect to filling the space between the lower board 14 and the substrate 1 with the washing water, which is filled into the space between the upper board 12 and the substrate 1 and flows out from sides of the substrate 1, by adjusting the flow rate of the washing water supplied from the pipe 13 so that the pipe 15 is unnecessary. Other components are the same as those of the example shown in Figure 1.

[0039] Figure 3 is a side view including some sections showing another example of the substrate treatment apparatus according to the present invention. This example slopes the substrate at a predetermined angle from ~~the~~ horizontal in the substrate moving direction while moving the substrate. The substrate treatment apparatus comprises a plurality of rollers 20, air knives 21a and 21b, an upper board 22, a pipe 23, a lower board 24 and a pipe 25. The installation height of each roller 20 becomes higher as its installation position is forward to the substrate moving direction. Thereby, the rollers 20 slope the substrate 1 at the predetermined angle ~~theta~~ θ 1 from the horizontal in the substrate moving direction while moving the substrate 1. The air knives 21a and 21b, the upper board 22 and the lower board 24 are installed slantingly according to a slope of the substrate 1. Other components are the same as those of the example shown in Figure 1.

[0041] Figure 4 shows an outline of another example of the substrate treatment apparatus according to the present invention. This example slopes the substrate at a predetermined angle from the horizontal in a direction perpendicular to the substrate moving direction while moving the substrate. The substrate treatment apparatus comprises a plurality of rollers 30, air knives 31a and 31b, an upper board 32, a pipe 33, a lower board 34 and a pipe 35. In Figure 4, the pipe 35 is hidden behind the lower board 34 and not seen. Each roller 30 is installed slantingly so that its one end becomes higher than another end. Thereby, the rollers 30 slope the substrate 1 at the predetermined angle ~~theta~~ θ 2 from the horizontal in the direction perpendicular to the substrate moving direction while moving the substrate 1. The air knives 31a and 31b, the upper board 32 and the lower board 34 are installed slantingly according to a slope of the substrate 1. The pipe 33 shifts to a higher side of the sloped upper board 32, and the pipe 35 shifts to a higher side of the sloped upper board 34. Other components are the same as those of the example shown in Figure 1.

[0044] Figure 5 is a side view including some sections showing another example of the substrate treatment apparatus according to the present invention. This example differs from the example shown in Figure 1 in ~~point of making a~~ that the diameter of rollers 40 are bigger and ~~making~~ also a space between a lower board 44 and the substrate 1 is smaller than

the diameter of the rollers 40. On the lower board 44, openings for exposing the rollers 40 are prepared, and the pipe 45 is installed at a certain position, which is shifted to the substrate moving direction from the center of the lower board 44. The pipe 45 fills the space between the lower board 44 and the substrate 1 with the washing water 2b by supplying the washing water at a predetermined flow rate. Other components are the same as those of the example shown in Figure 1.

[0045] Figure 6 is a side view including some sections showing another example of the substrate treatment apparatus according to the present invention. This example differs from the example shown in Figure 5 in ~~point of preparing~~ that a plurality of lower board 54, ~~which is~~ are arranged between two rollers 40. On each lower board 54, the pipe 55 is installed at a certain position, which is shifted to the substrate moving direction from the center of the lower board 54. Each pipe 55 fills a space between each lower board 54 and the substrate 1 with the washing water 2b by supplying the washing water at a predetermined flow rate. Other components are the same as those of the example shown in Figure 1.

[0046] According to the examples explained above, by preparing the upper board 12, 22 or 32 the predetermined distance apart above the substrate 1 and filling the space between the upper board 12, 22 or 32 and the substrate with the washing water 2a, it becomes possible to form the washing water layer evenly on the upper surface of the substrate 1 using ~~a~~ less ~~amount~~ of the washing water. Moreover, since the upper surface of the substrate 1 is covered by the upper board 12, 22 or 32, drops of the washing water, which are blown away with the air from the air knife 11a, 21a or 31a, do not adhere to the upper surface of the substrate 1. Therefore, it becomes possible to prevent watermarks being generated.

[0047] In the same way, by preparing the lower board 14, 24, 34, 44 or 54 ~~the~~ a predetermined distance apart below the substrate 1 and filling the space between the lower board 14, 24, 34, 44 or 54 and the substrate with the washing water 2b, it becomes possible to form the washing water layer evenly on the lower surface of the substrate 1 using ~~a~~ less ~~amount~~ of the washing water. Moreover, since the lower surface of the substrate 1 is covered by the

lower board 14, 24, 34, 44 or 54, drops of the washing water, which are blown away with the air from the air knife 11b, 21b or 31b, do not adhere to the lower surface of the substrate 1. Therefore, it becomes possible to prevent the watermarks being generated.

[0049] The same effect is obtained by heating the washing water 2a, which is filled into the space between the upper board 12, 22 or 32 and the substrate 1, or the washing water 2b, which is filled into the space between the lower board 14, 24, 34, 44 or 54 and the substrate 1. A mechanism for heating the washing water 2a or 2b (a heater and the like, for example) can be installed in the upper board 12, 22 or 32, the lower board 14, 24, 34, 44 or 54, or both. Alternatively, instead ~~Instead~~ of installing the mechanism for heating the washing water 2a directly in the upper board 12, 22 or 32, ~~the~~ a third flat component, which has ~~the~~ a mechanism for heating the washing water 2a, may be prepared between the upper board 12, 22 or 32 and the substrate 1. Similarly, instead of installing the mechanism for heating the washing water 2b directly in the lower board 14, 24, 34, 44 or 54, ~~the~~ a fourth flat component, which has ~~the~~ a mechanism for heating the washing water 2b, may be prepared between the lower board 14, 24, 34, 44 or 54 and the substrate 1.

[0059] The substrate 1 is mounted on the rollers 110 and moved in the substrate moving direction shown by an arrow with the rotation of the rollers 110. Each roller 110 is arranged a certain distance apart each other in the substrate moving direction and rotated at a predetermined speed by the drive equipment, which is not illustrated. As shown in Figure 8 (b), the installation height of each roller 110 becomes higher as its installation position is forward to the substrate moving direction. Thereby, the rollers 110 slope the substrate 1 at the predetermined angle ~~theta~~ θ 3 from the horizontal in the substrate moving direction while moving the substrate 1. Each roller 110 has flanges on its both ends for guiding the sides of the substrate 1.

[0060] Above the substrate 1 mounted on the rollers 110, the air knife 111a is prepared ~~through~~ across the width of the substrate 1 in the direction perpendicular to the substrate moving direction, wherein the air knife 111a is in parallel with the substrate 1. And

below the substrate 1 mounted on the rollers 110, the air knife 111b is prepared in the same way. The air knives 111a and 111b are constituted of a long casing, for example, wherein a pressure room is formed inside the casing and a slit-shape air passage led to the pressure room is prepared through its length. The air is supplied to the air knives 111a and 111b from the air supply equipment, which is not illustrated, and the air knives 111a and 111b emit the air from an end of the air passage evenly through its length.

[0061] Moreover, above the substrate 1 mounted on the rollers 110, the nozzle 112 is prepared ~~through~~ across the width of the substrate 1 in the direction perpendicular to the substrate moving direction, wherein the nozzle 112 is near the air knife 111a and in parallel with the air knife 111a. The nozzle 112 is constituted of a long pipe, for example, wherein a nozzle mouth is prepared in every certain length or as a slit through its length. The washing water is supplied to the nozzle 112 from the washing water supply equipment, which is not illustrated, and the nozzle 112 emits the washing water 2 from the nozzle mouth evenly through its length.

[0063] Beside the boundary 3a of the washing water layer 3 on the upper surface of the substrate 1, a side in the substrate moving direction becomes a dry area, where the washing water layer 3 is pushed away and removed by the air from the air knife 111a. On the other hand, in a non-dry area in an opposite side, the washing water layer 3 is always formed with the washing water 2, which is supplied from the nozzle 112. Therefore, even if the substrate 1 has ~~the~~ a strong water repellency ~~strongly~~ on its upper surface, line-shape stains will not be generated ~~unlike before~~ since the washing water layer 3 ~~has being~~ is formed on the upper surface of the substrate 1 just before drying. Moreover, ~~the~~ foreign matters do not remain ~~unlike before~~ along traces of small drops moved. Also, ~~And~~ the high washing effect and the high foreign matter removal effect are obtained by sloping the substrate 1 at the predetermined angle ~~theta~~ θ 3 from ~~the~~ horizontal while moving the substrate 1.

[0067] The substrate 1 is mounted on the rollers 120 and moved in the

substrate moving direction shown by an arrow with the rotation of the rollers 120. Each roller 120 is arranged a certain distance apart each other in the substrate moving direction and rotated at a predetermined speed by ~~the~~ drive equipment, which is not illustrated. As shown in Figure 10 (b), each roller 120 is installed slantingly so that its one end becomes higher than another end. Thereby, the rollers 120 slope the substrate 1 at the predetermined angle ~~theta~~ θ 4 from the horizontal in the direction perpendicular to the substrate moving direction while moving the substrate 1. Each roller 120 has flanges on its both ends for guiding the sides of the substrate 1.

[0068] Above the substrate 1 mounted on the rollers 120, the air knife 121a is prepared ~~through~~ across the width of the substrate 1 in the direction perpendicular to the substrate moving direction, wherein the air knife 121a is in parallel with the substrate 1. And below the substrate 1 mounted on the rollers 120, the air knife 121b is prepared in the same way. The air knives 121a and 121b are constituted similarly to the air knives 111a and 111b in Figure 8. In Figure 10 (b), an illustration of the air knife 121b is omitted.

[0069] Moreover, above the substrate 1 mounted on the rollers 120, the nozzle 122 is prepared ~~through~~ across the width of the substrate 1 in the direction perpendicular to the substrate moving direction, wherein the nozzle 122 is near the air knife 121a and in parallel with the air knife 121a. The nozzle 122 is constituted similarly to the nozzle 112 in Figure 8.

[0071] Beside the boundary 3a of the washing water layer 3 on the upper surface of the substrate 1, a side in the substrate moving direction becomes a dry area, where the washing water layer 3 is pushed away and removed by the air from the air knife 121a. On the other hand, in a non-dry area in an opposite side, the washing water layer 3 is always formed with the washing water 2, which is supplied from the nozzle 122. Therefore, even if the substrate 1 has ~~the~~ a strong water repellency ~~strongly~~ on its upper surface, the line-shape stains will not be generated ~~unlike before~~ since the washing water layer 3 has being formed on the upper surface of the substrate 1 just before drying. Moreover, ~~the~~ foreign matters do not remain ~~unlike before~~ along the traces of the small drops moved. And the high washing effect and the high foreign

matter removal effect are obtained by sloping the substrate 1 at the predetermined angle ~~theta~~ θ 4 from the horizontal while moving the substrate 1.

[0074] In the examples shown in Figure 8 and Figure 10, the position, where the boundary 3a of the washing water layer 3 appears, can be adjusted so as to obtain the best washing effect, the best foreign matter removal effect and the best drying effect by adjusting a moving speed of the substrate 1, the slope angle ~~theta~~ θ 3 or ~~theta~~ θ 4 of the substrate 1, a flow rate and a flow velocity of the air emitted from the air knife 111a or 121a, a flow rate and a flow velocity of the washing water emitted from the nozzle 112 or 122, a direction of the nozzle 112 or 122 (the incident angle of the washing water 2), a distance between the nozzle 112 or 122 and the substrate 1, etc.